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(54) Title: REDUCED GLOBAL POSITIONING SYSTEM RECEIVER CODE SHIFT SEARCH SPACE FOR A CELLULAR TELEPHONE SYSTEM
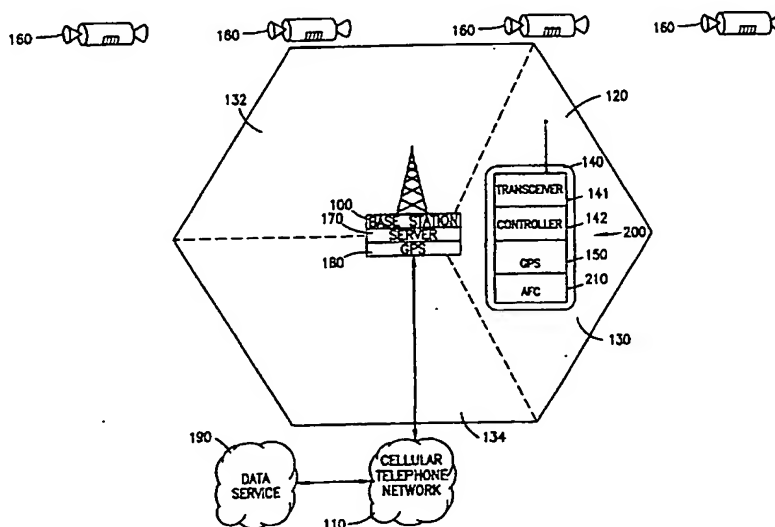
(57) Abstract

A Global Positioning System (GPS) receiver located at a base station of a cellular telephone network determines the location of the base station and obtains GPS ephemeris and, if available, timing information. A server uses the obtained information to calculate auxiliary information for use by a GPS receiver. The base station transmits the auxiliary information to the GPS receiver which is located within a cellular telephone operating within the service area of the base station. The cellular telephone GPS receiver uses the auxiliary information to determine the location of the cellular telephone and transmits location information to the cellular telephone network via the cellular telephone and the base station.

REDUCED GLOBAL POSITIONING SYSTEM RECEIVER CODE SHIFT
SEARCH SPACE FOR A CELLULAR TELEPHONE SYSTEM

BACKGROUND OF THE INVENTION
Technical Field of the Invention

5   The present invention pertains in general to a method and apparatus for reducing code shift search space in a Global Positioning System receiver, and more particularly, to reducing code shift search space in a Global
10   Positioning System receiver connected to a cellular mobile station operating within a cellular telephone system.

Description of Related Art

It is desirable, and likely to be mandatory in the
15   near future, that cellular telephone systems be equipped to determine the geographical location of cellular telephones operating within the cellular telephone system. To meet this requirement it has been proposed that cellular telephones be equipped with Global Positioning
20   System (GPS) receivers for determining the location of the cellular telephone. GPS receivers, however, are expensive, increase the cellular telephone size, and consume limited battery power available to the cellular telephone. Furthermore, GPS receivers do not function
25   well within buildings or in other areas where GPS satellite transmissions are weakened due to an obstruction, fading, reflecting, or the like.

It is commonly known that GPS receivers can be made smaller, less expensive, and more energy efficient by
30   eliminating certain GPS receiver functionality used to obtain auxiliary information normally obtained through the demodulation of GPS satellite signals. Instead of demodulating the GPS satellite signals, an alternative means is used to provide the GPS receiver with the needed
35   auxiliary information. This auxiliary information

includes various information such as a list of GPS satellites currently in view of the GPS receiver, Doppler shifts for the listed GPS satellites, and ephemeris data for each of the listed GPS satellites. Eliminating the need for the GPS receiver to demodulate the GPS satellite signals also allows the GPS receiver to integrate the GPS satellite signals over a longer period of time allowing for reception of weakened signals due to obstructions.

In order to calculate the auxiliary information for the GPS receiver, however, the approximate location of the GPS receiver must be known. Moreover, the closer the actual location of the GPS receiver to the location used in calculating the auxiliary information the smaller the resulting location search to be performed by the GPS receiver. For example, it is known that if the GPS receiver is given auxiliary information calculated to a location within a radius of one hundred miles of the actual location of the GPS receiver, the GPS receiver need not measure the actual range to the GPS satellites, but instead, only needs to measure a fraction of a millisecond for each of the ranges. This greatly simplifies the necessary range measurements to that of finding the relative code shift position locations to the one millisecond code cycle. In order to do this, however, the GPS receiver still must search all one thousand twenty three code shift positions for all the GPS satellites to be used in the location solution.

The code shift searches can be performed by means of a combination of a fast Fourier transform and an inverse fast Fourier transform correlator to simultaneously search all the code shift positions. This technique for finding the code shift position of a cyclic sequence is described in textbooks, such as <u>Digital Signal Processing</u> by Oppenheim & Shafer. While such an approach is more computationally efficient than a straight correlation, it is nonetheless, computationally intensive requiring additional functionality and consuming limited battery

power resources. Furthermore, with the opportunity to
convey information to the mobile unit to assist it in its
search for the GPS satellite ranges, this method then
becomes computationally inefficient as it consumes
5   computation cycles searching for many code shift positions
that are not possible.

Another solution to searching all one thousand twenty
three shift code positions is to build specific hardware
to search multiple code shift positions simultaneously.
10   To date, however, hardware specific solutions have not
been able to simultaneously search more than a fraction
of code shift positions thus requiring multiple searches
and lengthy time delays.

It would be advantageous, therefore, to devise a
15   method and apparatus to reduce the code shift search space
required to be performed by a GPS receiver and thus reduce
the functionality and time required for a GPS receiver to
determine its location. Furthermore, it would be
advantageous to devise a method and apparatus for a GPS
20   receiver to obtain auxiliary information for determining
its location.

SUMMARY OF THE INVENTION

The present invention comprises a full functionality
25   Global Positioning System (GPS) receiver located at either
a base station or at a remote location and connected to
a base station via a communication link. The full
functionality GPS receiver obtains GPS ephemeris and
timing information and communicates this information to
30   a server. Alternatively, the server can obtain the
ephemeris data from a data service via the cellular
telephone network obviating the need for placing a GPS
receiver at the base station. The server then processes
the information to calculate auxiliary information for use
35   by a reduced functionality mobile GPS receiver located
inside and connected to a cellular telephone operating
within the service area of the base station. The base

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station transmits the auxiliary information to the cellular telephone GPS receiver, either on demand by the remote unit, or periodically as a broadcast message. The GPS receiver in the cellular telephone then uses the auxiliary information to search for the code shift positions of all the appropriate codes within the signals coming from the GPS satellites. The pseudo ranges, indicative of the geographical location of the cellular telephone, are calculated from the code shift positions so measured. The cellular telephone then transmits the pseudo ranges to the cellular telephone network and the cellular telephone network calculates the geographical location of the cellular telephone. Alternatively, the cellular telephone determines its geographical location, using the GPS satellite locations derived from the ephemeris data supplied to it, and transmits the geographical location coordinates to the cellular telephone network.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

Figure 1 is a functional block diagram of a preferred embodiment of the present invention;

Figure 2 depicts a plurality of GPS satellites and a known and unknown location illustrating an example for predicting code shift positions;

Figure 3 illustrates conveyance of a time reference to a reduced functionality GPS receiver located within a cellular telephone; and

Figure 4 is a flow diagram of the preferred method for implementing the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS.

Referring now to Figure 1 there is illustrated a functional block diagram of a preferred embodiment of the present invention. A cellular telephone base station 100 located in a cell site 120 of a cellular telephone network 110 serves a cellular telephone 140. The cell site 120 is divided into a first sector 130, a second sector 132, and a third sector 134, with Figure 1 illustrating the cellular telephone 140 as being located within the first sector 130. The cellular telephone 140 also includes a reduced functionality GPS receiver 150 which receives GPS satellite transmissions from a plurality of GPS satellites 160. The reduced functionality GPS receiver 150 does not include functionality for demodulating GPS satellite 160 signals and determining auxiliary information. Instead, the auxiliary information necessary for determining location, and which also reduces the range of Doppler frequency shifts to be searched, is provided to the reduced functionality GPS receiver 150 from an alternate source. The present invention supplements the auxiliary information with a known location within the antenna pattern coverage area which, when combined with the GPS satellite 160 locations at the time the code shift positions are to be found, reduces the range of code shift positions to be searched from one thousand twenty three to a fraction of one thousand twenty three. The fraction is proportional to the distance between the actual location of the cellular telephone 140 and the known location. The fraction is on the order of the distance from the known location to the cellular telephone 140 in miles, divided by one hundred eighty six miles; one hundred eighty six miles being the distance corresponding to one millisecond of flight time of the GPS satellite 160 signals. The fraction is further determined by the accuracy of the time reference.

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In the preferred embodiment, the known location is either the location of the base station 100 or, alternatively, the center 200 of the sector 130 in which the cellular telephone is located. If a time reference is also conveyed by the base station 100, all code shift searches are reduced to a fraction of one thousand twenty three. If, on the other hand, a time reference is not conveyed by the base station 100, then all one thousand twenty three possible code shift positions are searched for a first GPS satellite 160 and only the fraction of one thousand twenty three code shift positions are searched for the remaining GPS satellites 160.

As stated earlier, the known location within the coverage area of base station 100 is used to calculate the auxiliary information. The location can be determined by any method including the use of a GPS receiver 180 located at the base station 100 or at a server 170 which calculates the auxiliary information. The base station 100 obtains and periodically updates GPS ephemeris information pertaining to the current status of the GPS satellites 160. In a preferred embodiment, the GPS ephemeris information is obtained by the base station 100 from a data service 190 via the cellular telephone network 110. Alternatively, the information can be obtained directly from GPS satellite 160 transmissions received by GPS receiver 180 located at the base station 100 or at the server 170. In the future, when an ancillary GPS related system known as Wide Area Augmentation System (WAAS) becomes operational, the GPS receiver 180 located at the base station 100 or at the server 170 will also be capable of obtaining differential correction information. The differential correction information allows GPS receivers to calculate their location with a higher degree of accuracy.

The server 170, located either at the base station 100 or at a remote location, uses information obtained from either the GPS receiver 180 or the data service 190

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to calculate auxiliary information which is subsequently
communicated to the base station 100 and transmitted to
the reduced functionality GPS receiver 150 located within
the cellular telephone 140. The auxiliary information
includes a list of GPS satellites 160 in view of the base
station 100, Doppler corrections for each of the listed
GPS satellites 160, and code shift positions for each of
the listed GPS satellites 160 based upon a universal time
coordinated time for the base station 100 location.

If the cell site 120 is divided into multiple sectors
and the base station 100 can determine the sector in which
the cellular telephone 140 is operating, in this example
the first sector 130, the server 170 calculates the
auxiliary information based on a center location 200 of
the sector 130. Calculating the auxiliary information
based on the center location 200 increases the accuracy
of the auxiliary information since there is a greater
probability that the cellular telephone 140 is located
closer to the center location 200 than the base station
100. The geographical coordinates for the center location
200 need not be at the actual center of the sector 130,
but instead, can be at a location where cellular
telephones are most likely to be located, for example at
a shopping mall, office complex, airport, or sporting
facility located with the sector. If, however, the cell
site 120 is not divided into multiple sectors or if the
base station 100 cannot determine the sector in which the
cellular telephone 140 is operating, the auxiliary
information is calculated based on the geographical
location of the base station 100.

In an alternative embodiment, the geographical center
location of a Business Transaction Area or Metropolitan
Service Area is used instead of the geographical location
of the base station 100. Every cellular telephone service
area is identified in a System ID (SID) which is read by
the cellular telephone 140. The cellular telephone 140
can either store auxiliary information pertaining to these

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locations and reference the information associated with the current SID or the auxiliary information is stored in the server and 170 and the cellular telephone provides the SID to the server 170 which provides the auxiliary

5 information.

After the server 170 calculates the auxiliary information, the base station 100 transmits the auxiliary information to the reduced functionality GPS receiver 150 in the cellular telephone 140. The auxiliary information

10 can be transmitted to the reduced functionality GPS receiver 150 in a variety of ways. For example, in a cellular telephone network using the Global System for Mobile communications protocol (GSM), information can be sent via a short messaging service message, packet data

15 message sent over a traffic channel, or a broadcast message over a control channel. The auxiliary information is sent in a manner consistent with methods commonly known in the industry for the transmission of information between the cellular telephone network 110 and the

20 cellular telephone 140. A transceiver 141 located within the cellular telephone 140 receives the transmissions from the base station 100 and a controller 142, also located within the cellular telephone 140, identifies the information as auxiliary information and provides the

25 reduced functionality GPS receiver 150 with the auxiliary information. Furthermore, the auxiliary information can be transmitted either on demand to a specific cellular telephone or to a plurality of cellular telephones via a broadcast channel.

30 To obtain a significant reduction in the code shift search space it is desirable that the timing coordination signal be accurate to within fifty microseconds or less of the universal time coordinated time used by the GPS system. Therefore, timing information is transmitted to

35 the reduced functionality GPS receiver 150 via the cellular telephone 140 in a variety of ways depending on the protocol of the cellular telephone network 110. For

example, in a digital protocol system such as GSM or IS-136 (Digital AMPS), the timing information is communicated via a message which states that a particular frame synchronization number will occur, or has occurred, at a certain time. In an analog Advanced Mobile Phone System (AMPS) system, a time tick consisting of a sharp pulse can be used to denote the reference time for determining the code shift positions for each GPS satellite 160.

The reduced functionality GPS receiver 150 located within the cellular telephone 140 makes use of the auxiliary information to measure code shift positions for each GPS satellite 160. For long integration times, for example 1 second, the actual code shift positions change up to 3 chips per second during the period. This change is compensated for by slipping the timing of the correlation code to stop the change prior to using the code shift position value in the location solution. The code shift positions are translated into delta ranges, measured for example in meters, to each GPS satellite 160. The delta ranges are calculated by subtracting the code shift positions measured from the code shift positions calculated for each GPS satellite 160 location obtained from the ephemeris data at the known location. A vector of these delta ranges, multiplied by the inverse of the matrix of unit vector cosines from the known location to each GPS satellite 160, yields the delta x, delta y, and delta z, from the known location.

Referring additionally now to Figure 2, there is illustrated a plurality of GPS satellites 220_{a-n}, a known location 230 and an unknown location 240 illustrating an example for predicting code shift positions. The calculations described below, are preformed by the server 170 and the predicted code shift positions are transmitted to the reduced functionality GPS receiver 150 as part of the auxiliary information. Alternatively, the calculation can be preformed by the reduced functionality GPS receiver 150. Each of the GPS satellites 220_{a-n} listed in the

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auxiliary information has a set of three dimensional coordinates $(X_{a-n}, Y_{a-n}, Z_{a-n})$. The known location 230 also has a set of three dimensional coordinates (X, Y, Z). A range R_{a-n} to each GPS satellite 220_{a-n} from the known location 230 is represented by the expression:

$$R_{a-n} = \sqrt{((X_{a-n}-X)^2 + (Y_{a-n}-Y)^2 + (Z_{a-n}-Z)^2)}$$

The signal propagation time T_{a-n} from each of the GPS satellites 220_{a-n} is represented by the expression:

$$T_{a-n} = R_{a-n} / (\text{speed of light})$$

The predicted code shift position C_{a-n} for each of the satellites 220_{a-n} is represented by the expression:

$$C_{a-n} = \text{fractional component of } [(T_{a-n} / 1000)] * 1023;$$

wherein T_{a-n} is divided by one thousand in order to express the signal propagation time in milliseconds and the fractional component of $(T_{a-n} / 1000)$ is used in order that the predicted code shift positions fall within zero to one thousand twenty three, the possible range of code shift positions.

Due to both uncertainties in the time reference and the fact that the unknown location 240, corresponding to the location of the cellular telephone 140, is located some distance from the known location 230, the search space around the predicted code shift positions are expanded to C_{a-n} plus and minus some offset number to create a code shift search space. The offset is based on the size of the service area and the uncertainty in the time reference wherein, larger service areas and increased uncertainty result in larger offsets with the uncertainty in the time reference being the predominant factor.

The reduced functionality GPS receiver 150 searches the code shift search space for the first satellite 220_a

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to determine an actual code shift position C'_a for the first satellite 220_a. Since the error is attributed predominantly to the accuracy of the time reference and not the distance between the unknown location 240 and the known location 230, the difference between the predicted code shift position C_a and the measured code shift position C'_a is added to the remaining predicted code shift positions C_{b-n}. This results in a more accurate prediction and thus, a smaller code shift search space. If the resulting predicted code shift positions C_{b-n} remaining after the offset has been added is greater than one thousand twenty three, one thousand twenty three is subtracted from the resulting predicted code shift positions C_{b-n} in order that the predicted code shift positions fall within zero to one thousand twenty three, the possible range of code shift positions.

If the time reference is unavailable, the initial code shift search for the first GPS satellite 220_a requires a search encompassing all one thousand twenty three possible code shift positions. After the initial search, however, the code shift search process for the remaining GPS satellites 220_{b-n} is identical to the process used when the time reference is available. Thus, the difference between the predicted code shift position C_a and the measured code shift position C'_a is added to the remaining predicted code shift positions C_{b-n} resulting in a more accurate prediction and thus, a smaller code shift search space. If the resulting predicted code shift positions C_{b-n} remaining after the offset has been added is greater than one thousand twenty three, one thousand twenty three is subtracted from the resulting predicted code shift positions C_{b-n} in order that the predicted code shift positions fall within zero to one thousand twenty three, the possible range of code shift positions.

A vector CD is created from the differences between the measured code shift positions C'_{a-n} and the predicted code shift positions C_{a-n}. These values are often

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expressed in meters by multiplying by the speed of light in meters per second. Multiplying the vector CD by an inverse of the matrix of cosines of unit vectors from the known location 230 to each of the GPS satellite locations at the measurement time yields a correction vector corrections for X, Y and Z which are added to the known location 230 to determine the unknown location 240.

Alternatively, instead of calculating the predicted code shift positions C_{a-n} as described above, the GPS receiver 180 located at the known position 230 can be used to measure the values directly. Using the GPS receivers, however, requires GPS receivers to be located at each base station.

Referring additionally now to Fig. 3, there is illustrated conveyance of a time reference to a reduced functionality GPS receiver 150 located within a cellular telephone 140. The distance R_a from the first GPS satellite 220_a to the known location 230 at the time of measurement is calculated in the manner described in Fig. 2, and the predicted code shift position C_a is calculated also in a manner described in Fig. 2. The same code shift position C_a is obtained in a correlator only if the base timing of the correlator code generator is properly synchronized with the GPS system. To obtain synchronization, the base timing of the GPS receiver 180 located at the base station 100 is set to yield the $\overline{C_a}$ code shift position as predicted. A reference point T_p on the base timing generator is selected and compared to the time of a base station 100 frame synchronization event T_x. The time difference between T_p and T_x is communicated to the base station 100 which communicates the difference to the reduced functionality GPS receiver 150 via the cellular telephone 140. The reduced functionality GPS receiver 150 uses the difference to set its internal timing base generator offset by an equal amount from its reception of the frame synchronization event.

Using any of a number of commonly known methods,
correlation is effectuated using either hardware or
software. Since the cellular telephone 140 is typically
located within ten miles or less of the serving base
5   station 100 and still closer to a central location 200,
the code shift position transmitted to the reduced
functionality GPS receiver 150 in the auxiliary
information is very close to the actual code shift
position for the location of the cellular telephone 140.
10   Therefore, the code shift search space which the reduced
functionality GPS receiver 150 must search is greatly
reduced.

Using standard GPS hardware with simultaneous search
engines (correlators), the reduced functionality GPS
15   receiver 150 searches for the code shift position of a
first GPS satellite 160 listed in the auxiliary
information. Since it is possible that the signal
strength of the first GPS satellite 160 to be searched
maybe very weak, a long correlation time is used to
20   achieve a processing gain. As an example, a one second
correlation achieves a twenty decibel processing gain.
Even at a very weak signal strength level, use of a
hardware correlator simultaneously searching two hundred
half code shift positions with a time reference accurate
25   to within fifty microseconds yields a one second long
parallel correlation of one hundred half code shift
positions on either side of the predicted code shift
position which is sufficient to find the exact code shift
position for the GPS satellite 160.

30   Alternatively, if the time reference is not provided
to the reduced functionality GPS receiver 150, a search
of all one thousand twenty three possible code shift
positions for the first GPS satellite 220_a is preformed
and once the actual code shift position is determined, an
35   internal time reference based on the predicted code shift
position for the first GPS satellite 220_a is calculated.

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Subsequent searches for the remaining GPS satellites 220_{b-n}
code shift positions are thus reduced accordingly.

When all code shift positions have been identified,
the reduced functionality GPS receiver 150 transmits the
resulting pseudo ranges to the cellular telephone network
110 via the cellular telephone 140 and the base station
100, whereupon, the server 170 determines the geographical
location of the cellular telephone 140. Alternatively,
the reduced functionality GPS receiver 150 can calculate
the geographical location using the pseudo ranges and
transmit geographical coordinates back to the cellular
telephone system 110 via the cellular telephone 140 and
the base station 100.

The pseudo ranges or geographical coordinates can be
transmitted to the cellular telephone network 110 in a
variety of ways. For example, in a cellular telephone
network using the Global System for Mobile communications
protocol, information can be sent via a Short Messaging
Service. The information is sent in a manner consistent
with methods commonly known in the industry for the
transmission of information between the cellular telephone
140 and the cellular telephone network 110. The
controller 142 identifies the information as pseudo ranges
or geographical coordinates and provides the information
to the transceiver 141 for transmission to the base
station 100.

In a second embodiment, the cellular telephone 140
is further equipped with an automatic frequency control
feedback 210 to lock the clock frequency of the cellular
telephone 140 to the carrier frequency of the base station
100. This allows Doppler corrections to be made with
sufficient accuracy such that only a few attempts at
Doppler correction are required to correlate the GPS
satellite 160 signals.

Referring additionally now to Figure 4, there is
illustrated a flow diagram of a preferred method for
implementing the present invention. The location of a

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base station of a cellular telephone network is determined
(step 300). A server located at the base station obtains
GPS ephemeris and, if available, timing information (step
305). The server obtains the GPS ephemeris information
5   either from a data service, or alternatively, from a GPS
receiver located at the base station.

The server calculates auxiliary information (step
310) and calibrates base station timing (step 315). The
server transmits the auxiliary and timing information
10   (step 320) to either an individual cellular telephone or
broadcasts the information to all cellular telephones via
a broadcast channel. The cellular telephone then
communicates the information to reduced functionality GPS
receiver located within the cellular telephone.

15   Using the transmitted data, the GPS receiver located
within the cellular telephone searches a code shift search
space of a first GPS satellite (step 330) to determine the
actual code shift position. Once the first code shift
position is located, the GPS receiver recalibrates its
20   timing (step 335) and corrects errors in the predicted
code shift positions for the remaining GPS satellites
(step 340). The GPS receiver then searches the remaining
code shift positions (step 350) and transmits location
information (step 360) to the cellular telephone network
25   via the cellular telephone and the base station.

Although embodiments of the method and apparatus of
the present invention have been illustrated in the
accompanying Drawings and described in the foregoing
Detailed Description, it will be understood that the
30   invention is not limited to the embodiments disclosed, but
is capable of numerous rearrangements, modifications and
substitutions without departing from the spirit of the
invention as set forth and defined by the following
claims.

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WHAT IS CLAIMED IS:

1.   An apparatus for reducing code shift searches in a reduced functionality global positioning receiver operating within a cellular telephone network comprising:

        means for obtaining global positioning system ephemeris information;

        a server for calculating auxiliary information based on a known location and the ephemeris information; and

        means for communicating the auxiliary information to the reduced functionality mobile global positioning receiver.

2.   The apparatus recited in claim 1, wherein the known location is a geographical center of a metropolitan service area.

3.   The apparatus recited in claim 1 further comprising a base station serving a cell site within which the reduced functionality global positioning receiver is located and wherein the known location is a location of the base station.

4.   The apparatus recited in claim 3, wherein the means for obtaining global positioning system ephemeris information is a full functionality global positioning receiver located at the base station.

5.   The apparatus recited in claim 3, wherein the means for obtaining global positioning system ephemeris information is a data service.

6.   The apparatus recited in claim 3, wherein the means for communicating the auxiliary information is a cellular telephone.

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7.   The apparatus recited in claim 6, wherein the auxiliary information is communicated via a control channel of the cellular telephone.

8.   The apparatus recited in claim 6, wherein the auxiliary information is communicated via a traffic channel of the cellular telephone.

9.   The apparatus recited in claim 6, wherein the auxiliary information is communicated via a short messaging service message of the cellular telephone.

10.   The apparatus recited in claim 3, wherein the server calculates the auxiliary information based on a center location of a sector of the cell site within which the global positioning receiver is located.

11.   An apparatus for determining the geographical location of a cellular telephone comprising:
            a transceiver located within the cellular telephone for receiving transmissions from a cellular telephone network containing auxiliary information; and
            a reduced functionality global positioning receiver located within the cellular telephone functioning to process the auxiliary information and calculates location indicating information.

12.   The apparatus recited in claim 11, wherein the reduced functionality global positioning receiver calculates pseudo ranges and transmits the pseudo ranges to the cellular telephone network.

13.   The apparatus recited in claim 11, wherein the reduced functionality global positioning receiver calculates geographical coordinates and transmits the coordinates to the cellular telephone network.

14. A method for reducing code shift search space in a reduced functionality global positioning system receiver operating within a cellular telephone network comprising the steps of:

5   determining a location of a base station serving a cell site of the cellular telephone network within which the global positioning system receiver is located;

obtaining global positioning system ephemeris information;

10   calculating auxiliary information from the ephemeris information for use by the global positioning system receiver to perform code shift searches; and

communicating the auxiliary information to the global positioning system receiver.

15

15. The method recited in claim 14, wherein the step of obtaining ephemeris information further includes the step of obtaining timing information.

20   16. The method recited in Claim 14, wherein the auxiliary information calculated by the cellular telephone network includes at least one of the following:

a list of satellites in view of the base station;

25   a Doppler correction for each of the satellites in view of the base station;

a code shift position for each of the satellites in view of the base station; and

a code shift position for each of the satellites

30 in view of the base station.

17. The method recited in Claim 14, further including the step of determining a sector of the cell site within which the global positioning system receiver is operating, and wherein the step of calculating the

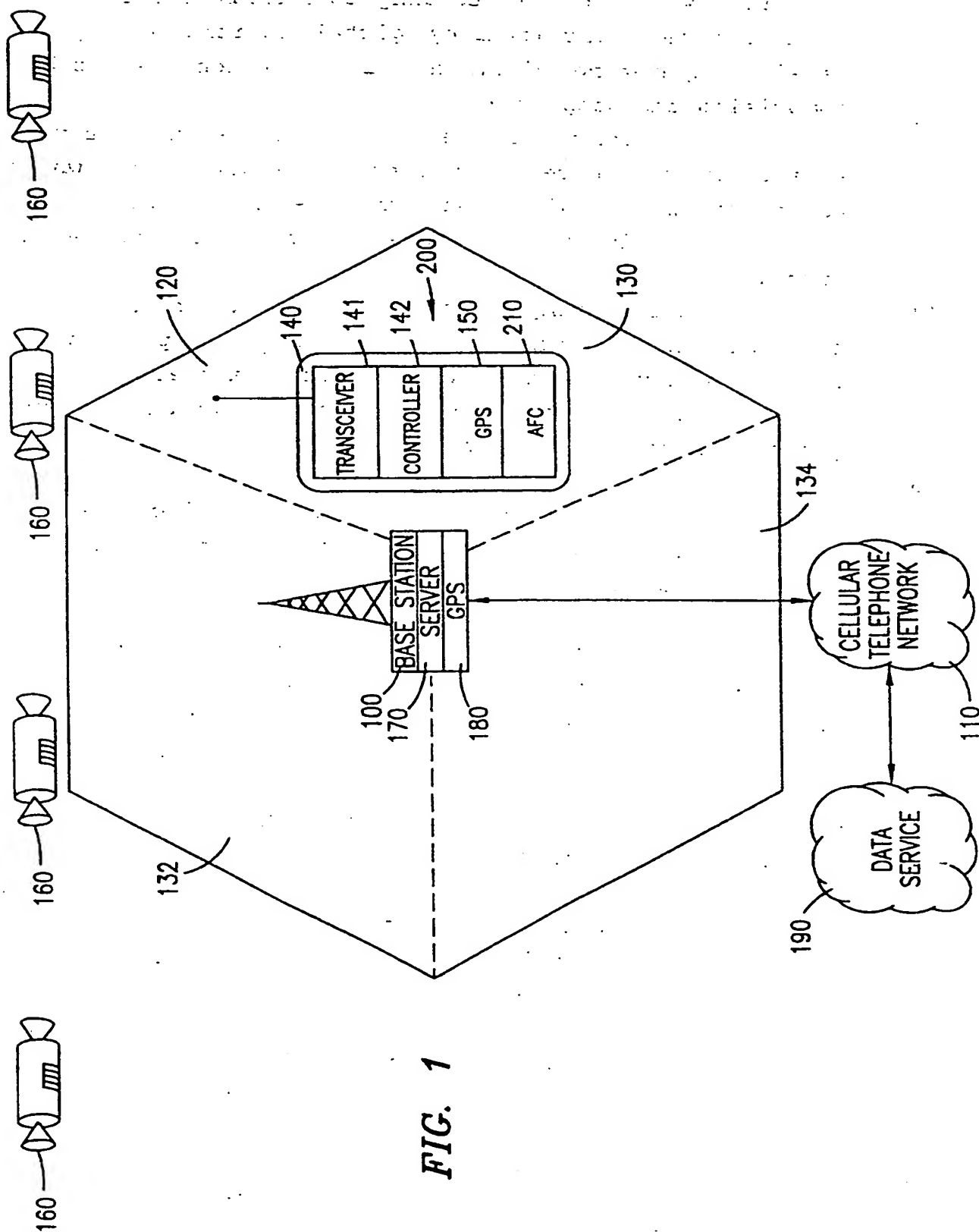35 auxiliary information by the cellular telephone network is based on the center location of the sector.
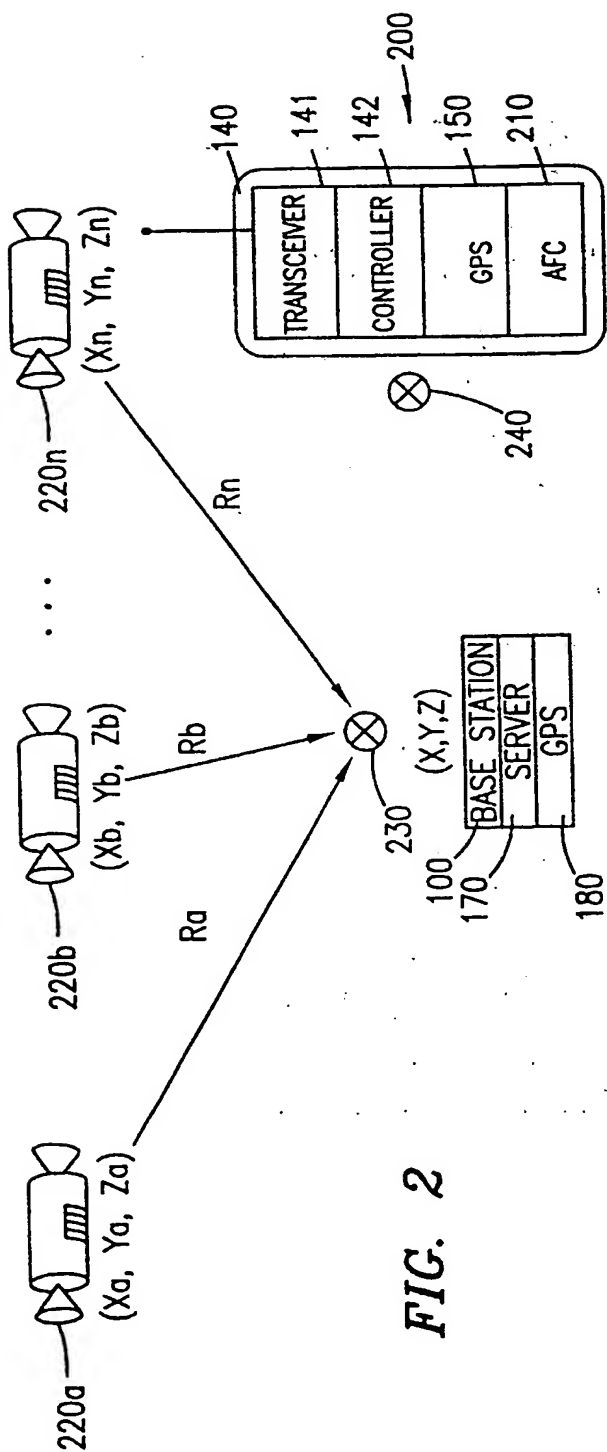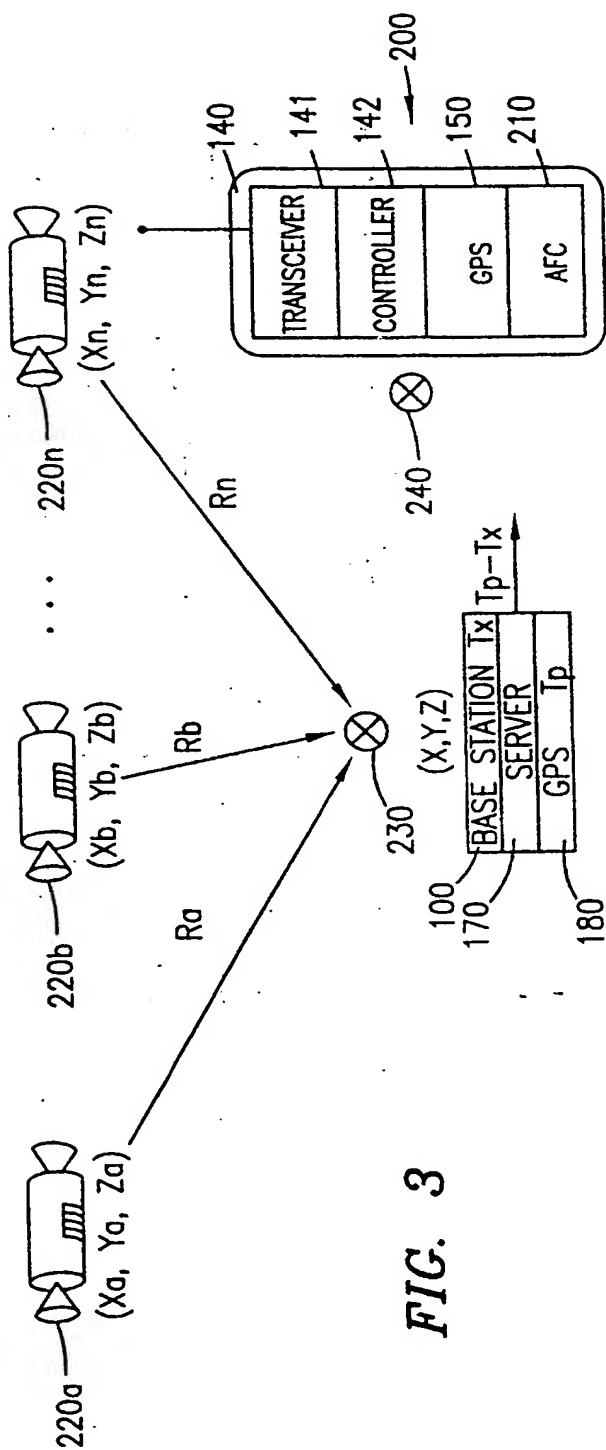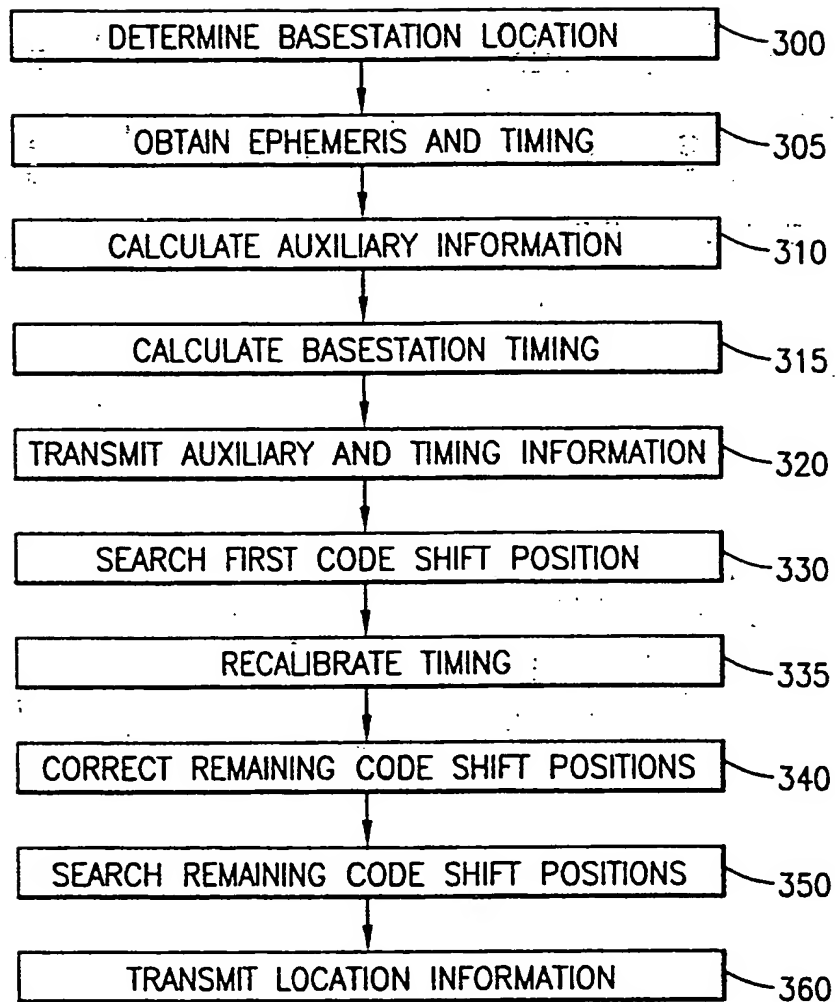
FIG. 1

FIG. 2

FIG. 3

DETERMINE BASESTATION LOCATION	─300
OBTAIN EPHEMERIS AND TIMING	─305
CALCULATE AUXILIARY INFORMATION	─310
CALCULATE BASESTATION TIMING	─315
TRANSMIT AUXILIARY AND TIMING INFORMATION	─320
SEARCH FIRST CODE SHIFT POSITION	─330
RECALIBRATE TIMING	─335
CORRECT REMAINING CODE SHIFT POSITIONS	─340
SEARCH REMAINING CODE SHIFT POSITIONS	─350
TRANSMIT LOCATION INFORMATION	─360

FIG. 4

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 : G01S5/14   G01S1/04   G01S5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   G01S   H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 33382 A (SNAPTRACK INC ;KRASNER NORMAN F (US)) 12 September 1997 see page 4, line 20 - line 29 see page 12, line 5 - line 8 see page 16, line 29 - line 31 see page 18, line 11 - line 14 ---	1,3-6, 11-15
X Y	GB 2 308 033 A (SYMMETRICOM INC) 11 June 1997 see page 6, line 24 - line 28 see page 5, line 3 - line 10 see page 6, line 1 - line 6 see page 6, line 12 - line 13 see page 7, line 24 - line 31 ---	1,3-6, 11,14,15 7-9

-/--

| X | Further documents are listed in the continuation of box C. |
| X | Patent family members are listed in annex. |

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 February 1999	22/02/1999

| Name and mailing address of the ISA
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category[3]	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 96 07110 A (MANNINGS ROBIN THOMAS ;BRITISH TELECOMM (GB); WALL NIGEL DAVID CHA) 7 March 1996 see page 10, line 7 - line 15 see page 15, line 4 - line 8	8;9
Y	GB 2 264 837 A (KOKUSAI DENSHIN DENWA CO LTD) 8 September 1993 see abstract see page 6, line 7 - line 8	7

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Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9733382	A	12-09-1997	US	5841396 A	24-11-1998
			AU	2070297 A	22-09-1997
			AU	7662096 A	30-04-1997
			CA	2230841 A	17-04-1997
			EP	0855039 A	29-07-1998
			EP	0885492 A	23-12-1998
			WO	9714049 A	17-04-1998
			AU	5587698 A	29-06-1998
			AU	5588898 A	29-06-1998
			WO	9825157 A	11-06-1998
			WO	9825158 A	11-06-1998
GB 2308033	A	11-06-1997	AU	1036797 A	27-06-1997
			CA	2238949 A	12-06-1997
			EP	0866983 A	30-09-1998
			WO	9721109 A	12-06-1997
WO 9607110	A	07-03-1996	AU	684228 B	04-12-1997
			AU	3393195 A	22-03-1996
			AU	695816 B	20-08-1998
			AU	5538998 A	23-04-1998
			CA	2198886 A	07-03-1996
			DE	69506563 D	21-01-1999
			EP	0777863 A	11-06-1997
			EP	0837341 A	22-04-1998
			FI	970848 A	28-02-1997
			JP	10505420 T	26-05-1998
			NO	970940 A	28-02-1997
			NZ	292210 A	28-07-1998
GB 2264837	A	08-09-1993	JP	5232210 A	07-09-1993